

What is claimed is:

1 An engine starter for rotating a reciprocating engine having a plurality of top dead centers comprising:

5 a starter motor energized by a battery, said starter motor including an armature, a series-wound first field coil having a predetermined current limiting resistance and a parallel-wound second field coil; and

a short-circuiting means for short-circuiting said first field coil
10 after said starter motor rotates the engine to surmount a first top dead center;

wherein said current limiting resistance limits main current supplied to said armature to an amount to provide a sufficient torque of the starter motor to surmount the first top dead center but to prevent
15 terminal voltage of the battery from dropping to a predetermined minimum level.

2. The engine starter according to claim 1,

wherein said short-circuiting means short-circuits said first field
20 coil when the main current decreases to a predetermined level.

3. The engine starter according to claim 1,

wherein said short-circuit means short-circuits said first field coil when a predetermined time has passed after the main current is supplied to
25 the armature.

4. The engine starter according to claim 1,

wherein:

said first field coil comprises a plurality of magnetic pole cores and a plurality of series-connected first coil-sections respectively mounted on said pole cores; and

5 said second field coil comprises a plurality of parallel-wound second coil sections connected in parallel with each other and a series-wound second coil section respectively mounted on said pole cores.

5. The engine starter according to claim 1,

10 wherein:

said first field coil comprises a plurality of magnetic pole cores and a plurality of first coil-sections respectively mounted on said pole cores to form a parallel circuit of said series-connected first coil sections; and

15 said second field coil comprises a plurality of parallel-connected second coil sections respectively mounted on said pole cores and respectively connected in series to said parallel circuit.

6. The engine starter according to claim 4,

20 wherein said first coil-section comprises a wire having a smaller diameter than said plurality of parallel-connected second coil sections.

7. The engine starter according to claim 4,

25 wherein said second field coil is connected in series to said first field coil and in parallel with said armature.

8. The engine starter according to claim 4,

wherein said second field coil is connected in parallel with said first field coil and said armature.

9. The engine starter according to claim 1,

5 wherein said second field coil is connected in series to said first field coil and in parallel with said armature.

10. The engine starter according to claim 7, further comprising a control element for controlling current supplied to said parallel-wound coil,

wherein said control element is connected in series to said parallel-wound coil.

11. The engine starter according to claim 7, further comprising second short-circuiting means for short-circuiting said series-wound second coil section.

12. The engine starter according to claim 11,

20 wherein said second short-circuiting means comprises a relay and a control circuit for controlling said relay according to one of a plurality of conditions which includes an amount of current supplied to said starter motor, a current supply time, an engine rotation speed and an engine rotation angle.

25 13. The engine starter according to claim 12,

wherein said control circuit changes control timing of said relay according to a vehicle condition.

14. An engine starter driven by a battery comprising:

a power supply line having a main switch;

a starter motor including an armature, a series-wound field coil and

5 a parallel-wound field coil, said armature, said series-wound field coil
being connected to the battery via said power supply line when said main
switch is closed;

field current control means for controlling current supplied to said
parallel-wound field coil; and

10 voltage-drop control means, connected in series to said power line,
for controlling voltage drop of the battery to be less than 2 volts when said
main switch is closed to supply current to said armature,

wherein said starter motor is arranged to have a torque to surmount
a first top dead center when voltage of the battery decreases by 2 volts
15 from its normal voltage.

15. The engine starter according to claim 14,

wherein said voltage-drop control means comprises a member for
limiting current supplied to said armature.

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16. The engine starter according to claim 15,

wherein said voltage-drop control means further comprises a short-
circuiting relay, connected in parallel with said member for limiting
current, for short-circuiting said member when it is turned on and a relay
25 control means for switching said relay from a turn-off state to a turn-on
state when a predetermined condition is assumed.

17. The engine starter according to claim 16,

wherein said relay control means switches said short-circuiting relay from a turn-off state to a turn-on state if one of the following conditions is met: when a predetermined time has passed; when engine
5 rotation speed becomes a predetermined level; and when the current supplied to said armature decreases to a set amount.

18. The engine starter according to claim 14,

wherein said field current control means supplies said parallel-
10 wound field coil with a maximum amount of field current when the engine starter drives the engine and a set amount of field current after said short-circuiting relay is switched from the turn-off state to the turn-on state.

19. The engine starter according to claim 18,

15 wherein said field current control means supplies said parallel-wound field coil with a set amount of field current after the current supplied to the armature increases and thereafter decreases.

20. The engine starter according to claim 18,

20 wherein said field current control means supplies said parallel-wound field coil with a set amount of field current when the engine continues to rotate after surmounting a first top dead center.

21. The engine starter according to claim 18,

25 wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so as to maximize the output power of said starter motor.

22. The engine starter according to claim 18,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so as to keep the voltage of the battery higher than a predetermined level.

23. The engine starter according to claim 18,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so as to keep the rotation speed of the engine higher than a predetermined level.

24. The engine starter according to claim 18,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so as to keep the main current supplied to said armature at a predetermined level.

25. The engine starter according to claim 24,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so that the set amount of field current is changed according to a difference between an actual amount of the main current and the set amount of the main current when the actual amount is detected.

26. The engine starter according to claim 24,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so that the set amount of the field current is changed according to a difference between a predetermined voltage of the battery and an actual voltage of the battery.

27. The engine starter according to claim 24,

wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so that the set amount
5 of the field current is changed according to a difference between a predetermined rotation speed of the engine and an actual rotation speed of the engine.

28. The engine starter according to claim 25,

10 wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so that said starter motor can output a maximum power.

29. The engine starter according to claim 25,

15 wherein said field current control means supplies said parallel-wound field coil with a set amount of field current so that the voltage of the battery can be higher than a predetermined voltage.

30. The engine starter according to claim 25,

20 wherein the set amount of field current is controlled so that the rotation speed of the engine can be kept rotating at a predetermined rotation speed.

31. The engine starter according to claim 24,

25 wherein said field current control means changes the set amount of field current and said main current according to an engine starting condition.

32. The engine starter according to claim 31,

wherein said field current control means supplies said parallel-wound field coil with a set amount of the field current at least when said engine is started by an ignition key.

33. The engine starter according to claim 31,

wherein said field current control means supplies said parallel-wound field coil with a set amount of the field current so that the engine can rotate at a predetermined rotation speed if an abnormality is detected when the engine is being started.

34. The engine starter according to claim 14, further comprising means for alarming when the battery voltage drop becomes larger than 2 volts.

35. The engine starter according to claim 34, further comprising means for disabling said means for alarming at a predetermined condition.

36. The engine starter according to any one of claims, characterized in that said field current control means controls field current supplied to said parallel-wound field coil according to a change in an engine load so that voltage change can be controlled within 0.3 volts.